EG&G Idaho, Inc.

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INTERNAL TECHNICAL REPORT

Title: CPP-633 NaK FURNACE CHARACTERIZATION

Organization: Waste Programs Division

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CPP-633 NaK FURNACE CHARACTERIZATION

1. INTRODUCTION

The Waste Programs Division of EG&G Idaho, Inc., and Exxon Nuclear Idaho Company (ENICO) have completed a physical and radiological characterization of the NaK heating system. This system is part of the Waste Calcining Facility (WCF) at the Idaho Chemical Processing Plant (ICPP). This work was performed in anticipation of possible decontamination and decommissioning (D&D) of this system. The WCF, building CPP-633, is shown in Figure 1.

This report describes the original NaK heating system and identifies the remaining components of this system. Surface radiological contamination, radionuclides present, and radiation field are reported.

In addition, an estimate of the weight and volume of the contaminated components is also given.

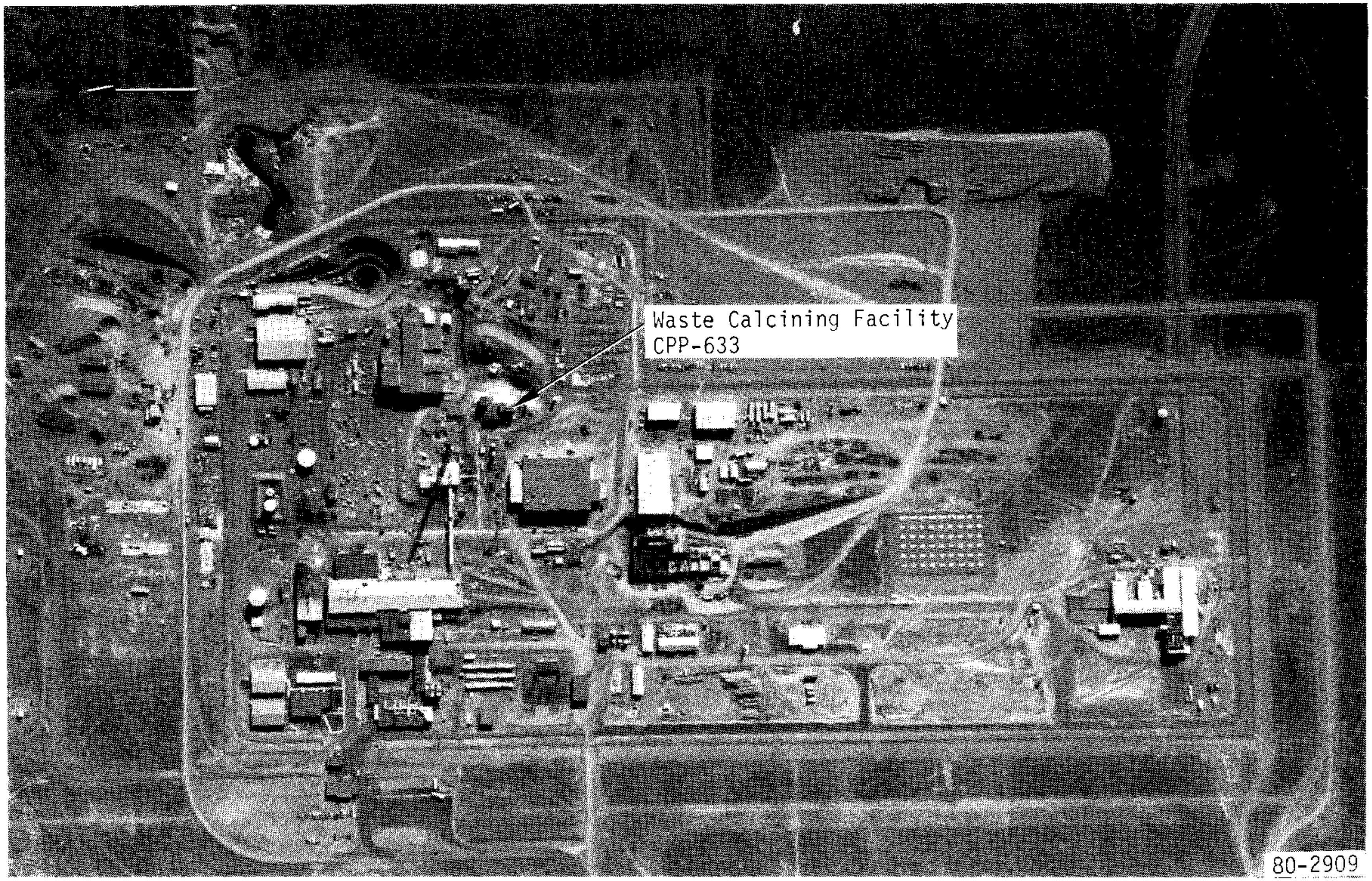

Figure 1. Idaho Chemical Processing Plant, looking east.

2. ICPP WASTE CALCINING FACILITY HISTORY

The WCF was the world's first plant-size facility built and operated to achieve safe, efficient disposal of high-activity radioactive wastes resulting from reprocessing nuclear fuels. The WCF began operation in 1963, following 2 years of testing using simulated wastes.

The WCF uses the fluidized bed technique to convert liquid radioactive waste to solids. A diagram of the fluidized bed waste calcining process is shown in Figure 2. This process is accomplished by spraying the waste solution into the calciner containing a bed of alumina particles which have been fluidized with air and heated to 400°C. The heat required for calcination of these wastes was provided by circulating liquid NaK which transferred heat from an oil-fired furnace to the calciner shown in Figure 2.

In 1971, the NaK system was replaced with in-bed combustion of kerosene and oxygen. This conversion was necessitated by failures in one or more parts of the NaK system causing unscheduled shutdowns of the WCF.

After conversion of the calciner vessel (WC 102) to in-bed combustion, the NaK was removed from the NaK system, along with several system components.

The NaK furnace, which had previously been used for heating NaK and fluidizing air, was modified and used only for heating fluidizing air. This modification permitted fluidizing air to be heated by the radiant coil as well as by the fluidizing air coil.

The fluidizing air system has since been modified, and the fluidizing air is heated by an electric furnace located in the NaK furnace room. Since this change, the NaK furnace has been inoperative.

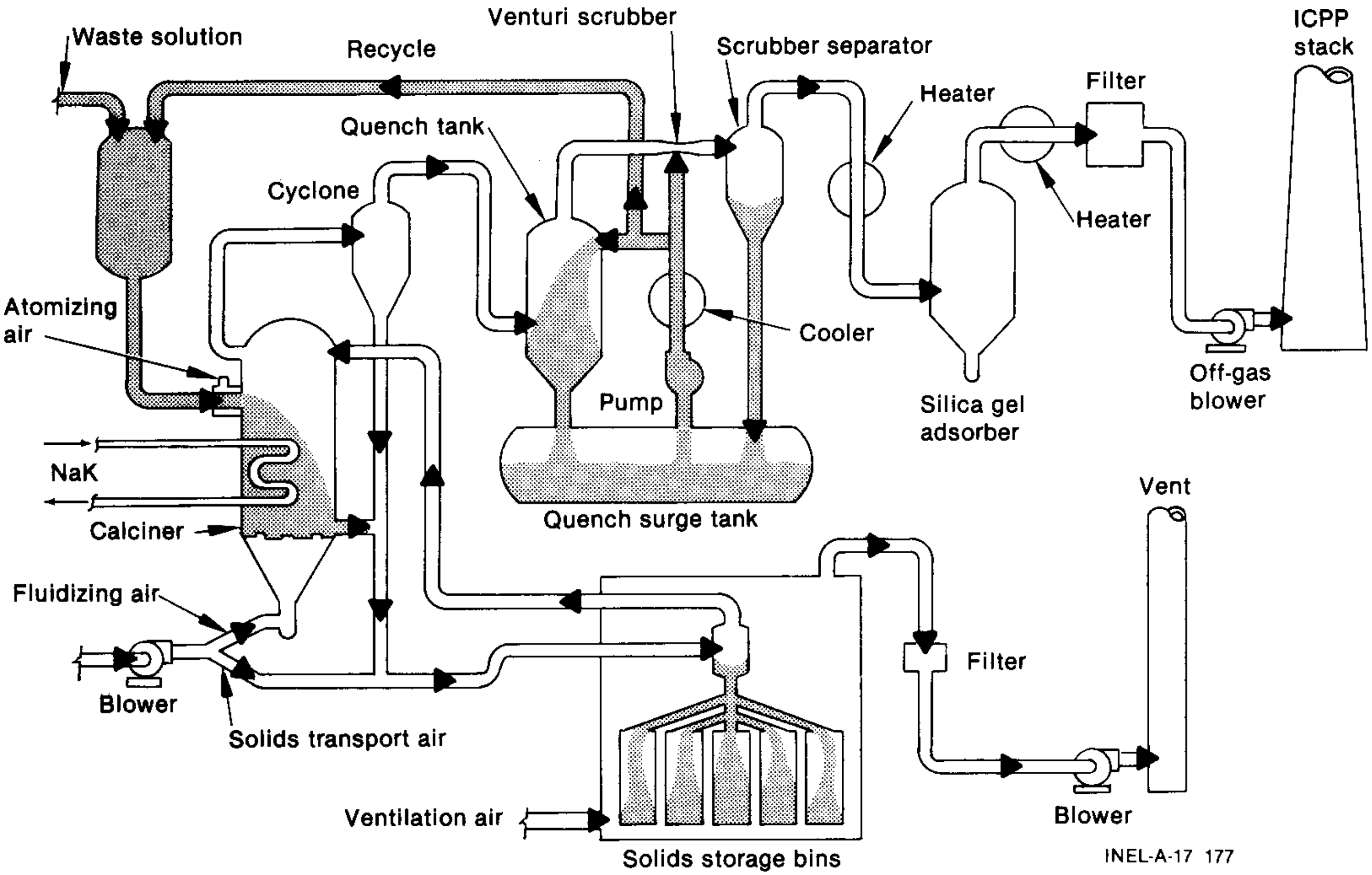

Figure 2. Fluidized bed waste calcining facility.

3. NaK SYSTEM DESCRIPTION

3.1 Original NaK System

A flow diagram of the original NaK system is shown in Figure 3.

The heat required for decomposition of the calciner feed was supplied through an indirect heat transfer system. An eutectic liquid metal (NaK) was pumped through a 3-in. stainless steel pipe to the oil-fired NaK furnace (WC-304), where the temperature was raised to a maximum of 760°C; past expansion tanks, which allowed for an increase of 25% of the cold volume; to the fluidized bed heat exchanger (WC-302), where it was cooled approximately 110°C; then back to the pump. The system differed from conventional heat transfer systems in that the design of certain components was peculiar to liquid metal systems. These included the NaK pump, flowmeters, and oxide removal system. In addition, the fluidized bed heater was constructed with specially designed "duplex tubes" in order to provide additional safety features for that part of the NaK loop in contact with radioactivity.

3.2 Existing NaK System

Most of the original NaK system was removed following the conversion of the calciner vessel (WC-102) to in-bed combustion. The NaK furnace and heater blower are essentially all that remain of the original NaK system. All removed components are denoted in Figure 4 by dark, heavy lines.

The remaining components are described in Table 1. Photographs of the remaining components, including fluidizing air piping, are shown in Figures 5 through 9.

A drawing of the NaK furnace is shown in Figure 10. The furnace consists of a vertical, squirrel cage radiant coil (modified to heat fluidizing air in the fire box section), and a fluidizing air preheating coil in the connection section. The radiant coil was originally used as a NaK heater until an in-bed combustion system was installed on the calciner vessel.

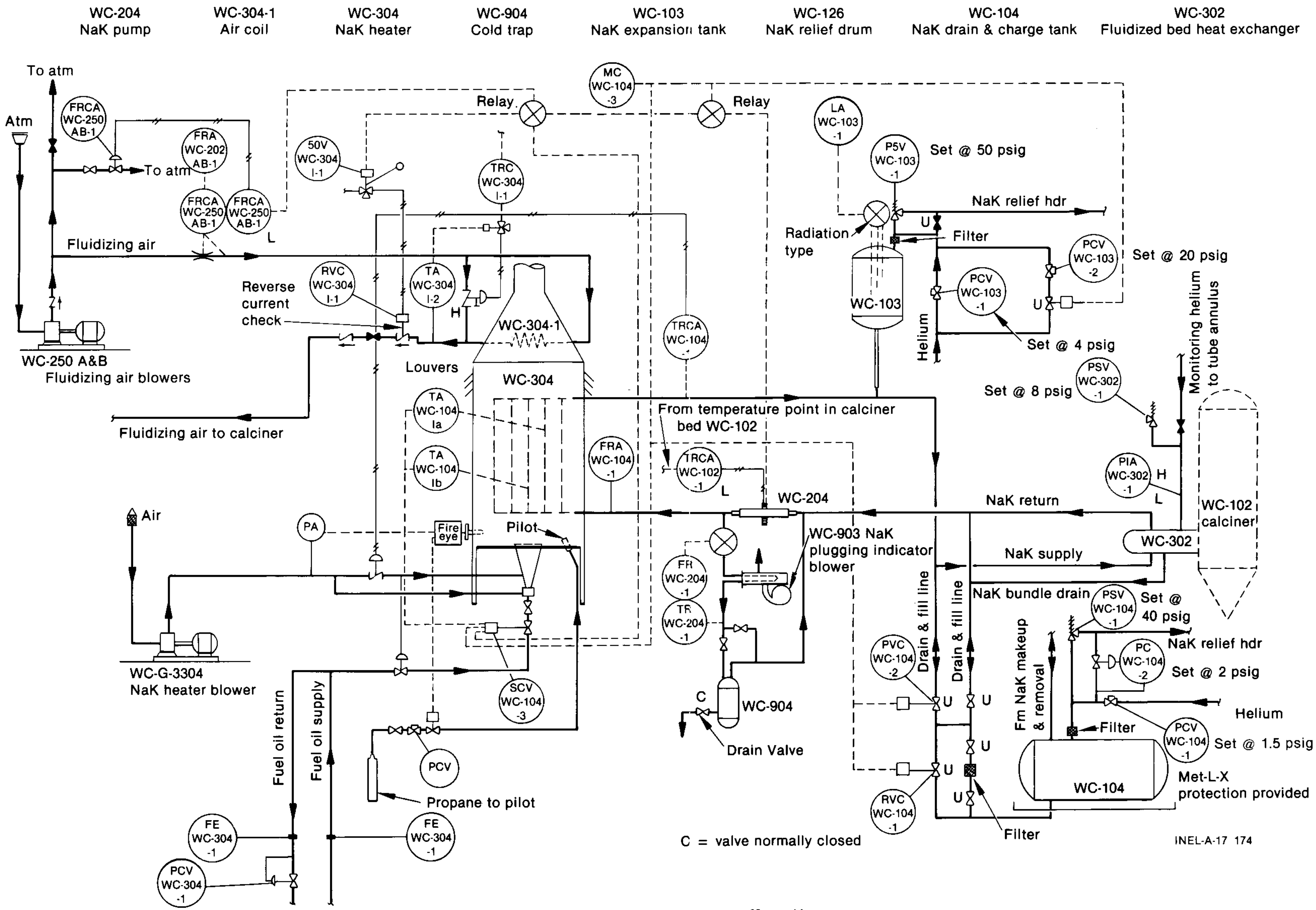

Figure 3. Original NaK system, flow diagram.

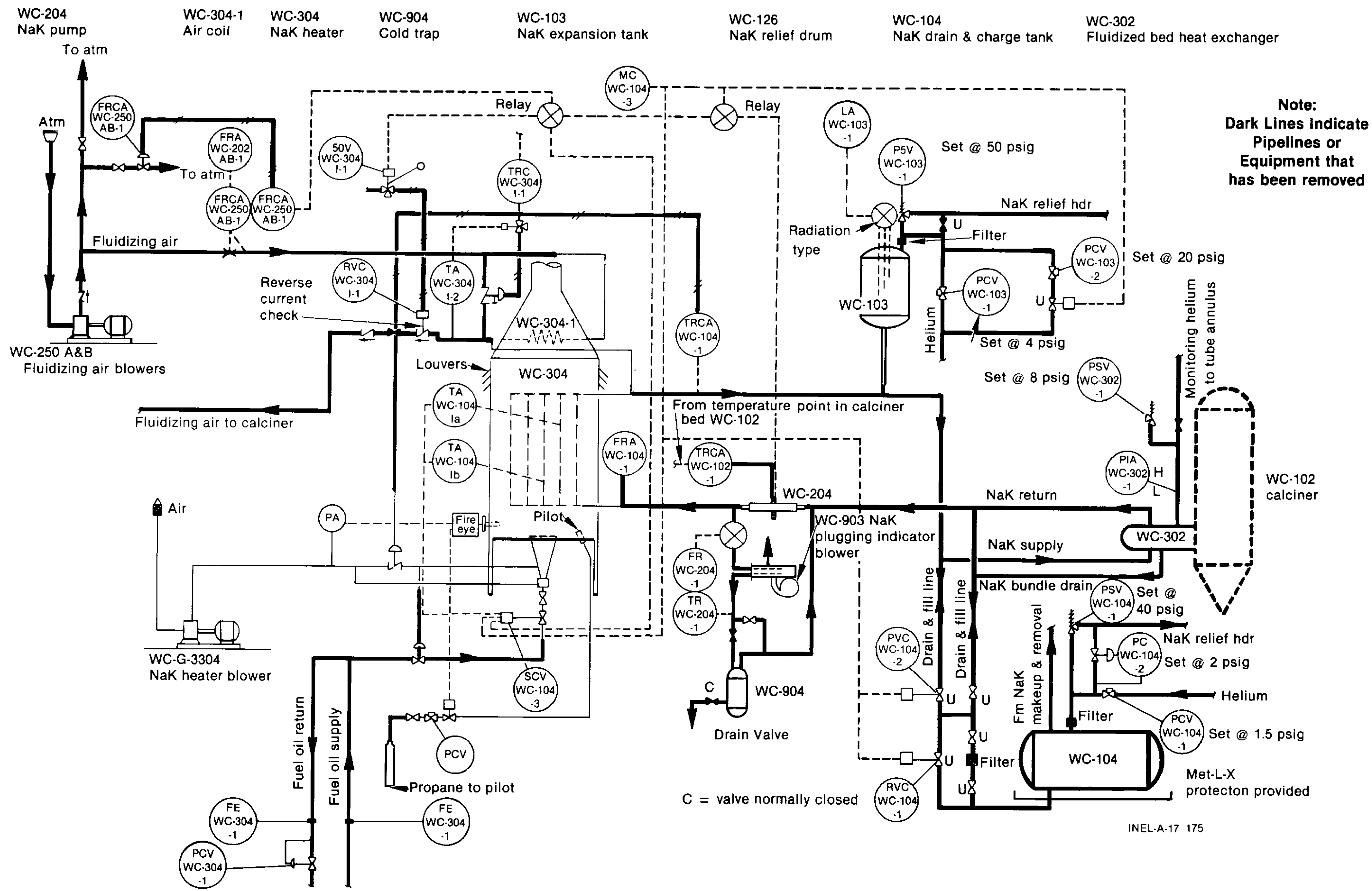

Figure 4. Nak system flow diagram showing remaining components.

TABLE 1. DESCRIPTION OF NaK EQUIPMENT

Equipment	Description
WC-304 NaK Furnace	Cylindrical structure with 7 in. of castable refractory lining on fire box and 3 in. of lining on connection section; overall height 40 ft, including a 14-ft-high stack; OD 5.2 ft; total volume 600 ft^3; total weight 18,000 lb
WC-G-3304 NaK Heater Blower	Turboblower with motor: 40-in.-dia circular blower housing with a total volume of 8 ft^3 and a weight of 250 lb; 12-in.-dia, 17-in.-long blower motor with a total volume of 6.2 ft^3 and a weight of approximately 150 lb

Figure 5. View toward ceiling of NaK furnace showing caged ladder and platform and part of original fluidizing air piping.

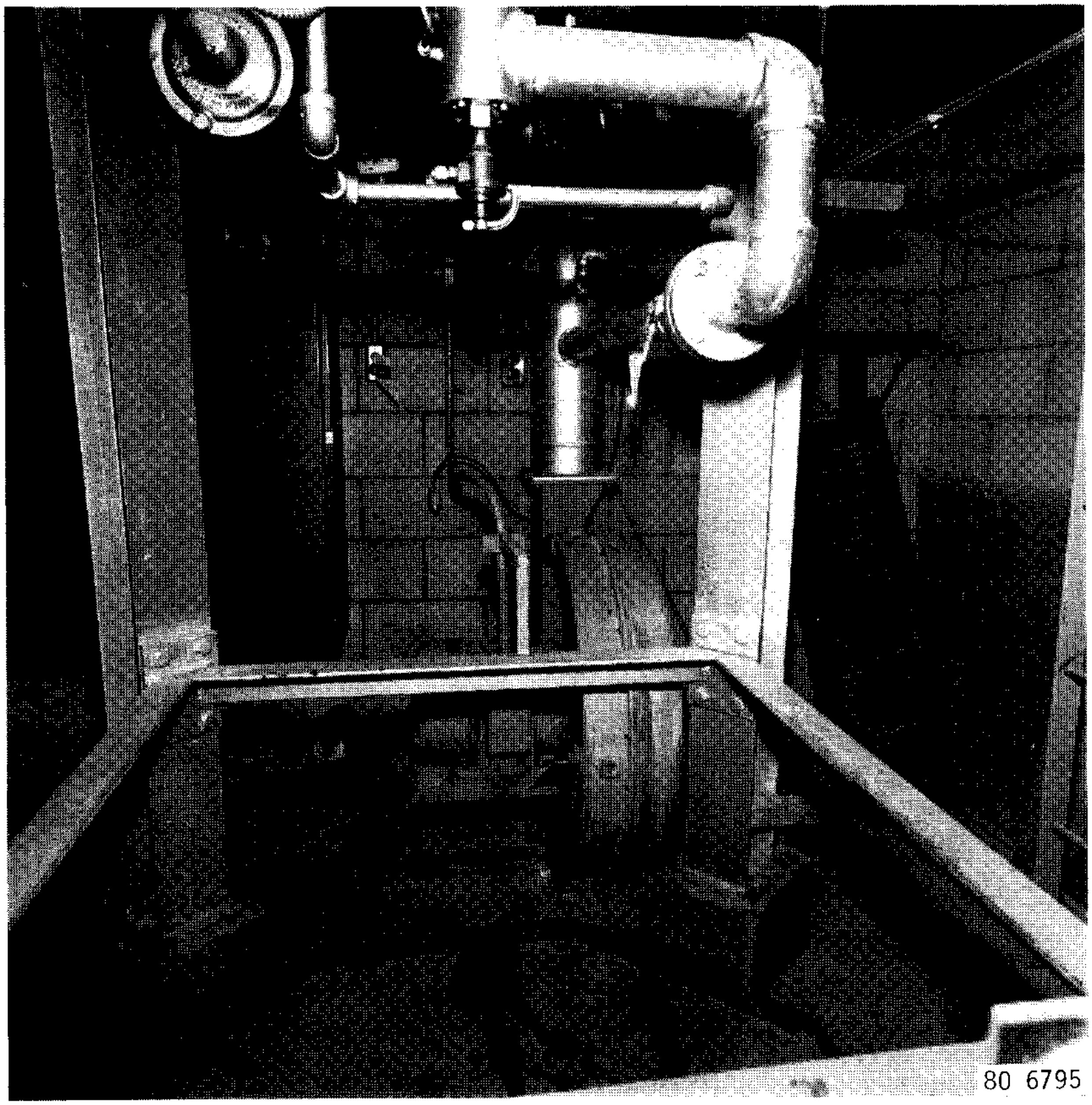

Figure 6. View of NaK furnace blower.

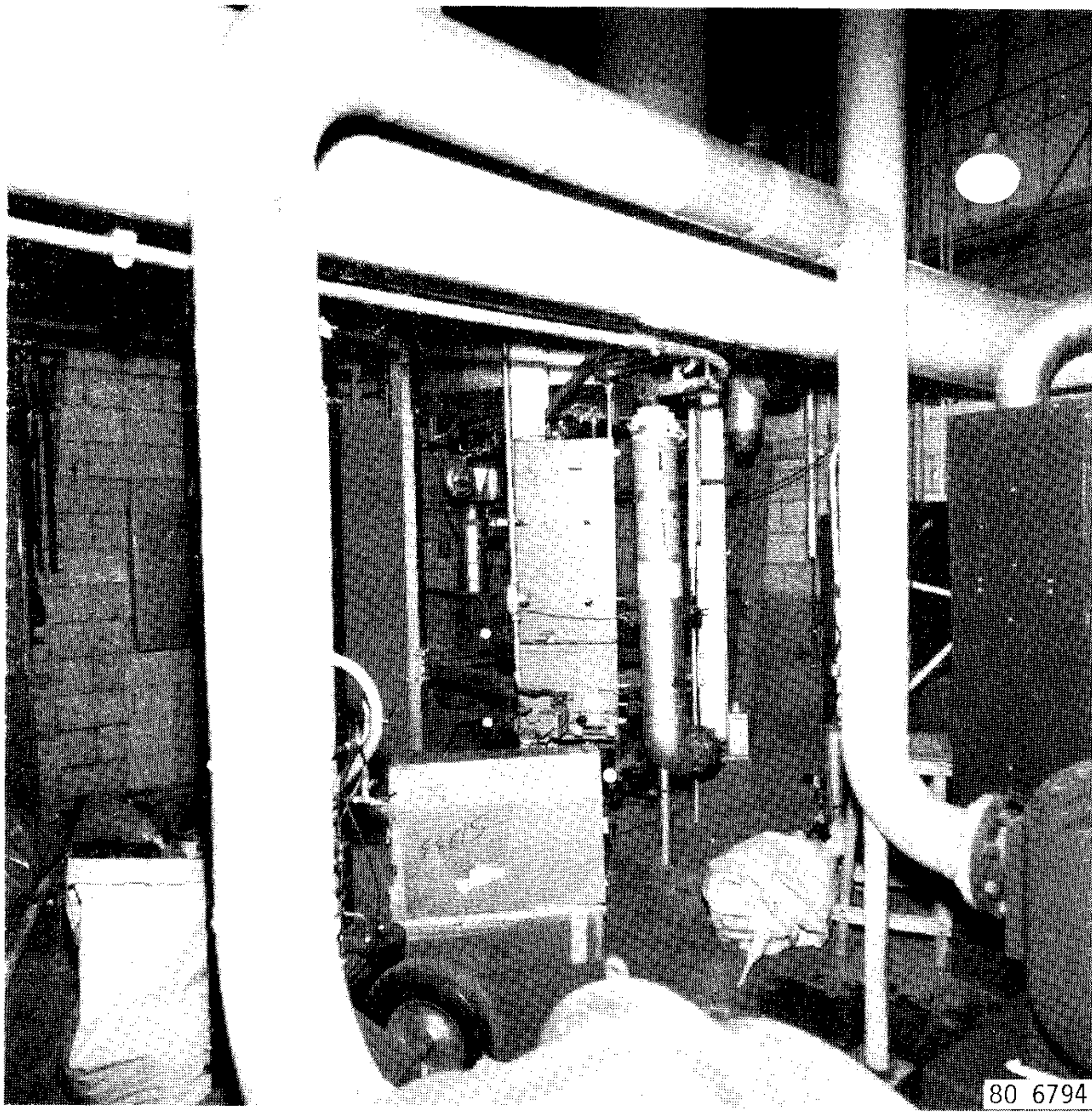

Figure 7. View of bottom of NaK furnace showing support structures and new fluidizing air piping.

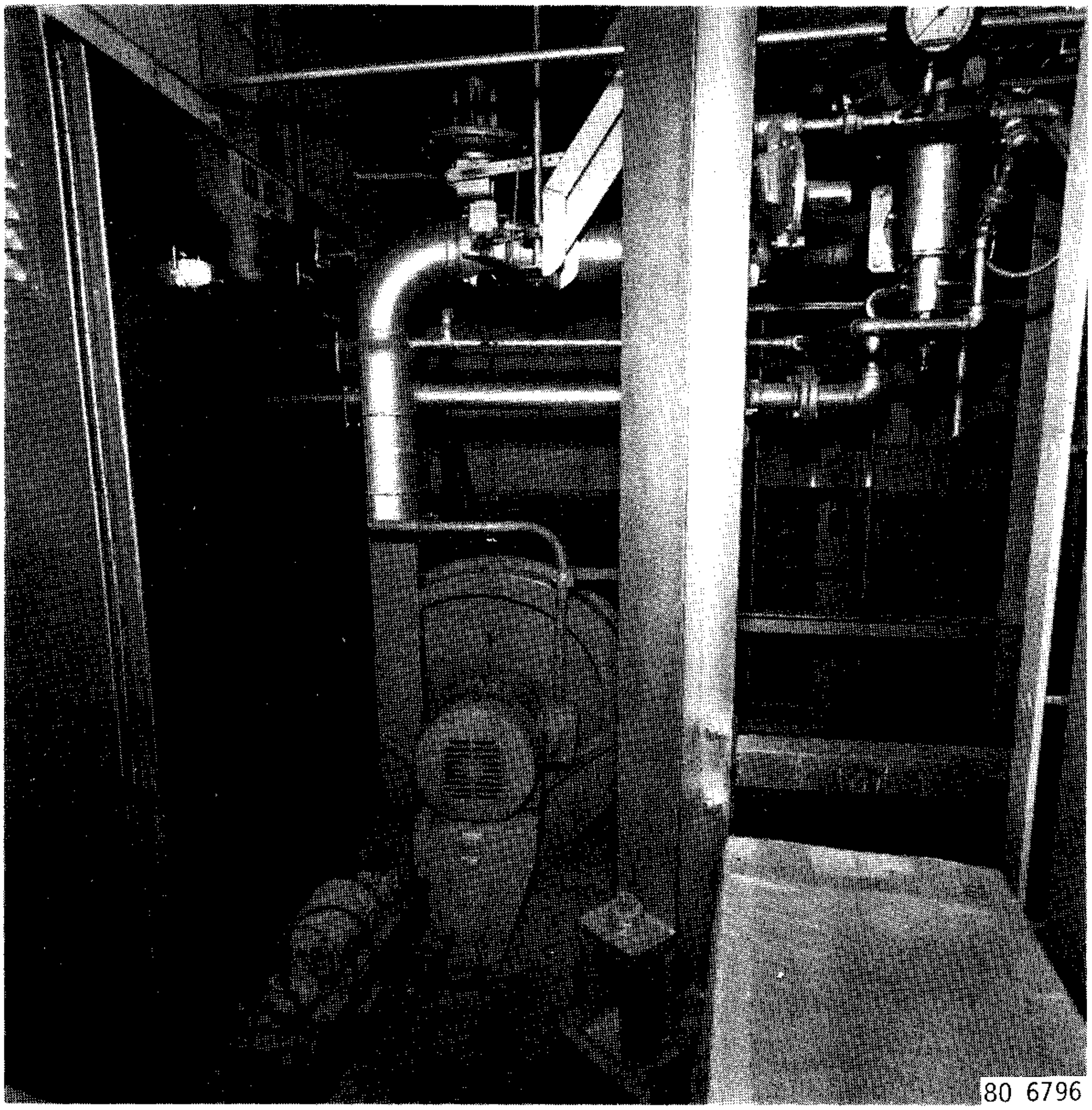
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Figure 8. View of bottom of NaK furnace showing blower, support structure, and piping.

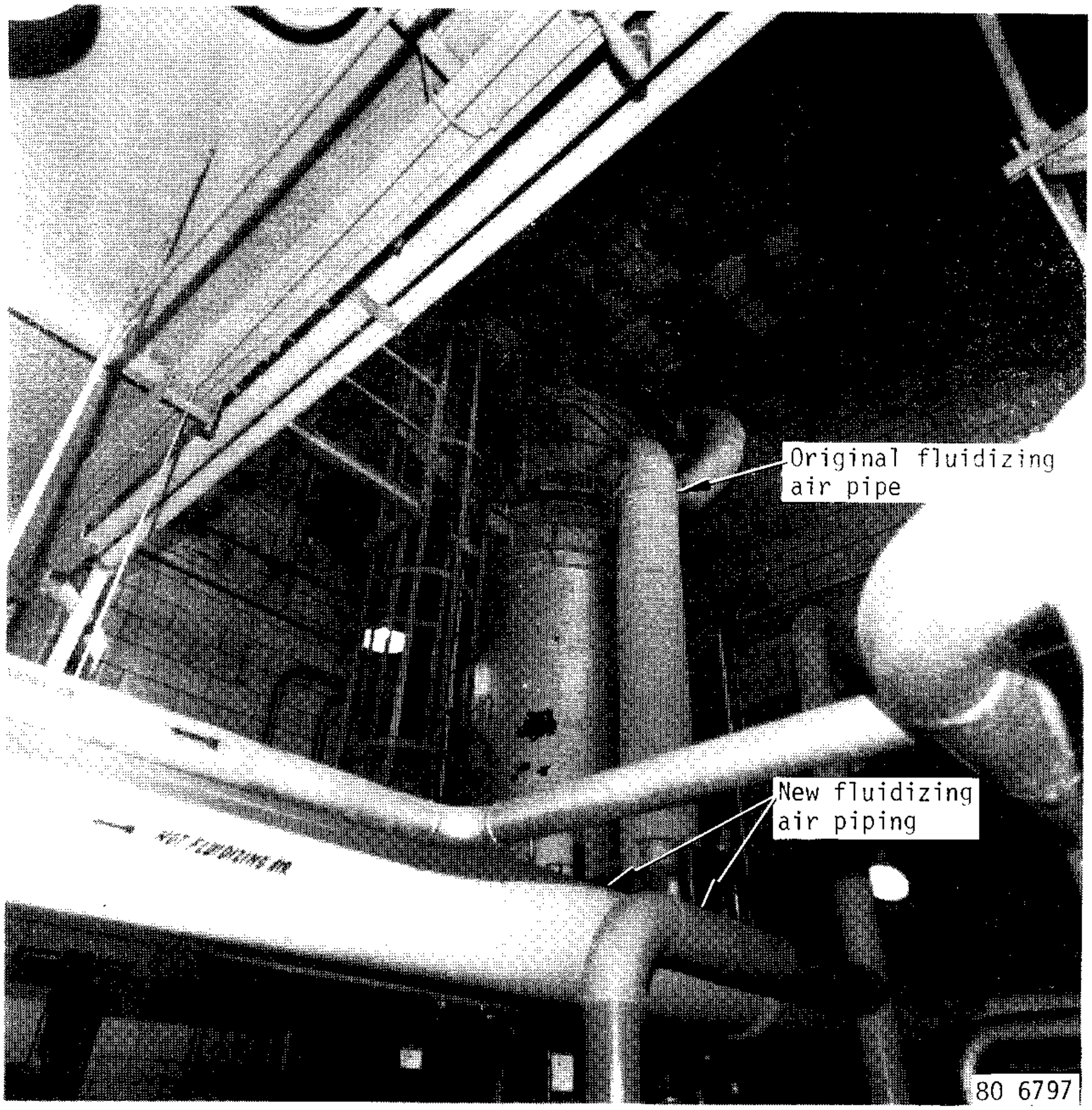

Figure 9. View toward ceiling of NaK furnace showing duct through roof and fluidizing air lines on side.

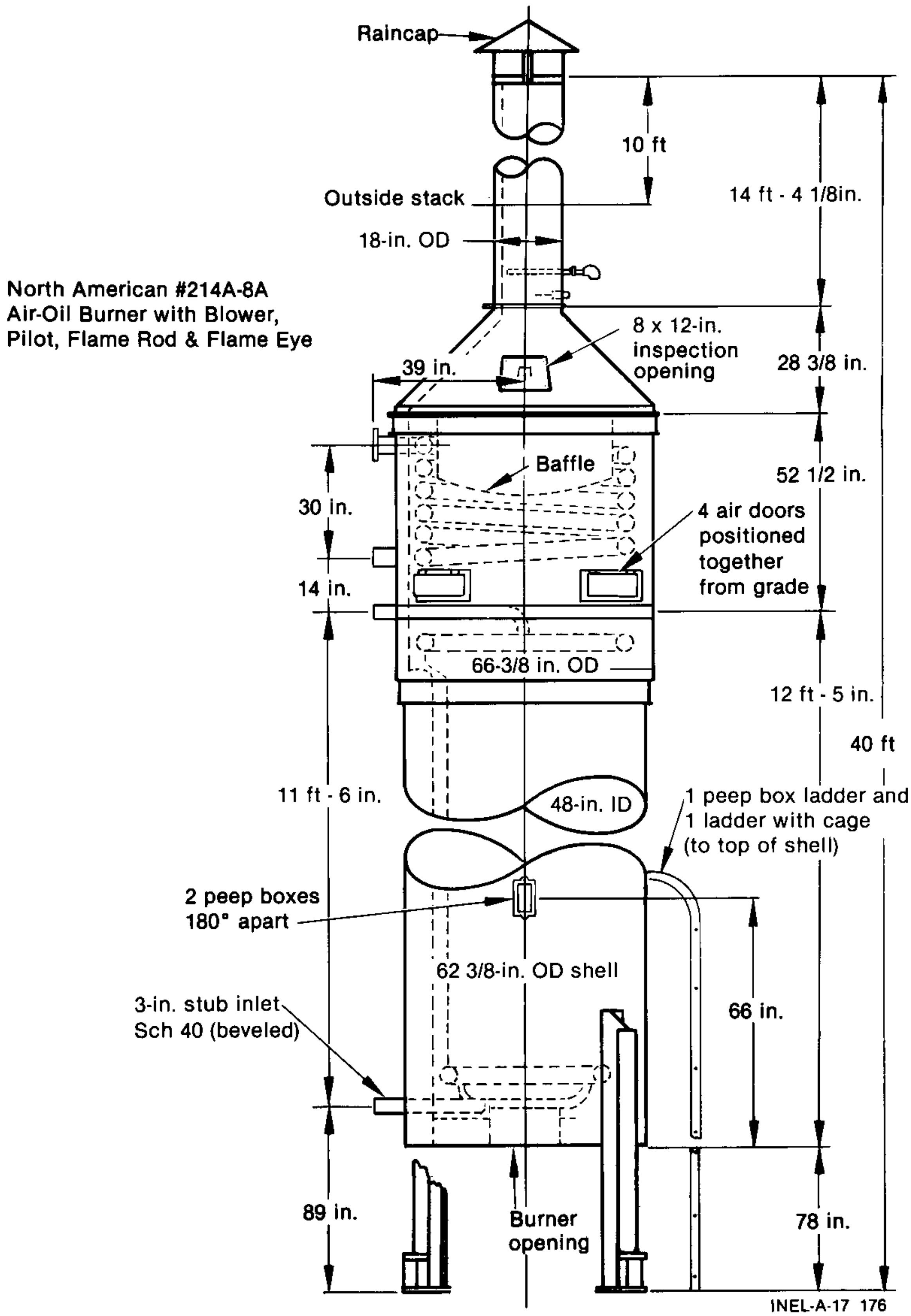

Figure 10. Drawing of NaK heater.

4. CHARACTERIZATION PERFORMED AND RESULTS

4.1 Radiation Survey

The radiation field was measured on the outside surface of the NaK furnace and the fluidizing air piping using a Ludlum 14C GM meter. In addition, a field measurement was made inside the furnace and fluidizing air pipe using the existing penetrations; i.e., inspection opening, air doors, peep hole, and open end of air pipe. The radiation field survey of the furnace surface generally showed radiation levels of 5 mR/h (β) over the top half and 5 mR/h (γ) over the bottom half. The radiation fields at the penetrations are shown in Figure 11.

The NaK furnace room interior walls were also surveyed using the Ludlum 14c. The radiation field produced by contamination on the walls was too low level to be detected above background.

4.2 Contamination Survey

Smears were taken every 60 degrees around the circumference of the NaK furnace at 5-ft vertical increments. The results of these measurements are shown over the furnace surface in Figure 11. The center of the ladder on the west side of the furnace is defined as zero degrees and the degrees are counterclockwise looking down on the furnace.

Smears were taken from the furnace room interior walls at randomly selected spots, and the smears were counted in the lab. Contamination on the walls measured 200 to 600 dpm (β). Negligible gamma and alpha contamination is present on the walls.

4.3 Radioisotopic Analysis

Contamination smears were taken from the NaK furnace surface, furnace blower surface, and inside the fluidizing air piping. The smears were dissolved and analyzed at the ICPP radiochemistry laboratory. The results of this analysis are shown in Table 2.

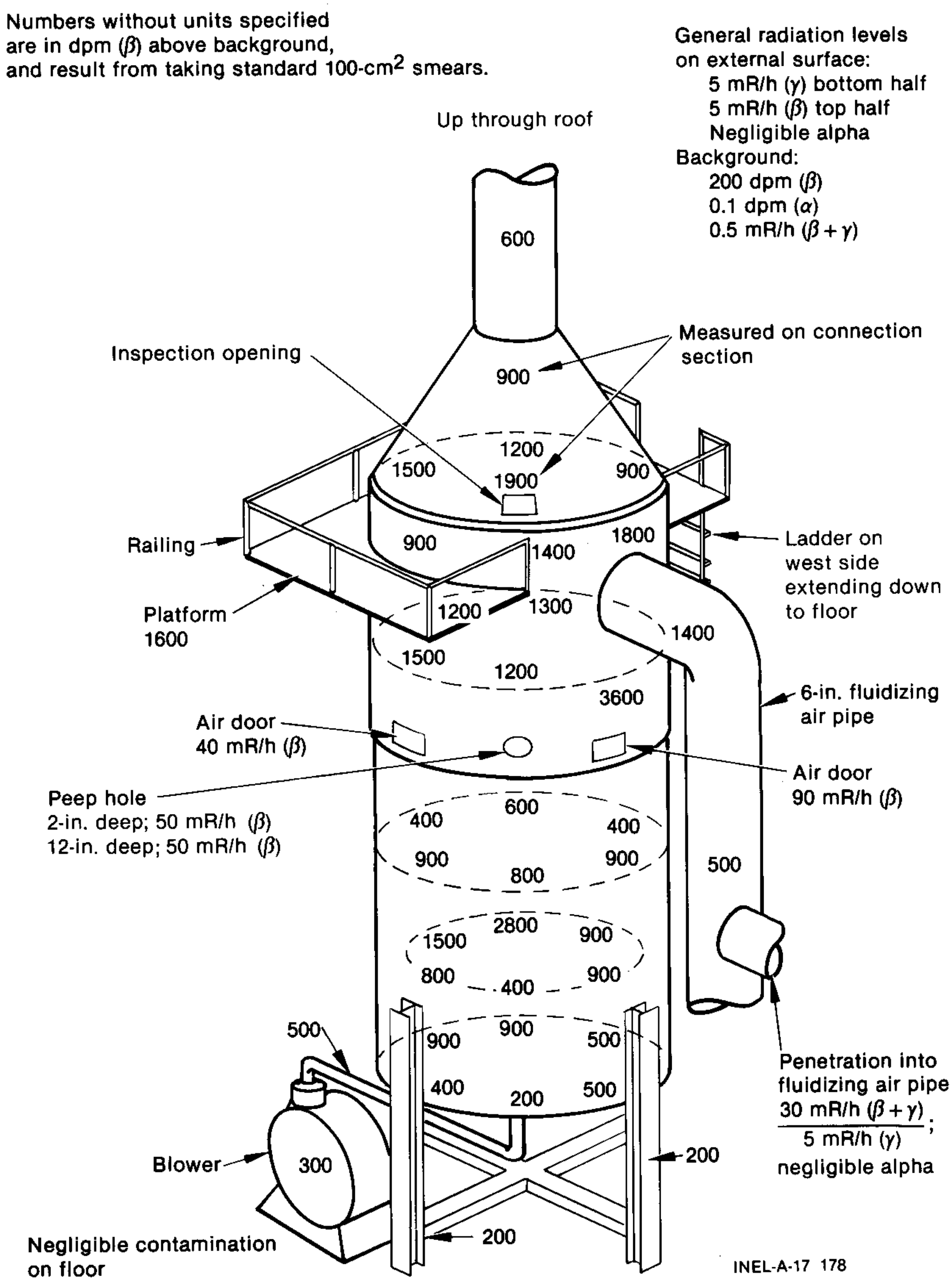

Figure 11. Radiation field and contamination survey of NaK furnace.

TABLE 2. RADIOISOTOPES PRESENT IN NaK FURNACE SYSTEM

Sample	Radioisotope and Activity
Smear from NaK furnace exterior	TRU:[a] <5 dps/sample
	Uranium: <2.5 μg/sample
	FP[b] (β, γ): 68 dps/sample
	Principal FP: ^{137}Cs, ^{90}Sr, ^{134}Cs
Smear from furnace blower	TRU: <5 dps/sample
	Uranium: <2.5 μg/sample
	FP (β, γ): 103 dps/sample
	Principal FP: ^{137}Cs, ^{90}Sr, ^{134}Cs
Smear from inside fluidizing air pipe	TRU: <5 dps/sample
	Uranium: <2.5 μg/sample
	FP (β, γ): 4500 dps/sample
	Principal FP: ^{137}Cs, ^{90}Sr, ^{134}Cs

a. Transuranic isotopes.

b. Fission products.

5. ESTIMATED WASTE WEIGHT AND VOLUME

The estimated weight and volume of the contaminated waste are shown in Table 3. The electric motor for the NaK furnace blower is not included because it can be salvaged. The asbestos volume consists of the insulation around the remaining original fluidizing air piping shown in Figure 5.

Most of the waste can be melted down in the smelter except the asbestos insulation. The waste volume after smelting is shown in Table 3.

TABLE 3. WASTE WEIGHT AND VOLUME ESTIMATES BEFORE AND AFTER SMELTING

Item	Material	Weight (lb)	Volume (ft^3)	Volume After Smelting[a] (ft^3)
NaK Furnace WC-304	Steel	18,000	600	40
NaK Furnace Blower	Steel	250	8	0.6
External Piping	Stainless Steel	575	7	1.3
Piping Insulation	Asbestos	268	38	N/A
Misc.[b]	Steel	1,600	16	3.6
	Total	20,693	669	45.5

a. Assume an average density of 450 lb/ft^3.

b. Miscellaneous includes support structure, ladder, platform, and control panel.

6. POTENTIAL PROBLEM AREAS

6.1 Asbestos

The two original fluidizing air pipes shown in Figure 5 are covered by 7 in. of asbestos insulation. These pipes are 6 in. in diameter, and have a total length of 25 ft. Removal of this asbestos requires special procedures in order to avoid health hazards. These procedures will be specified in the D&D plan.

6.2 Residual NaK

The NaK was removed from the NaK heating system prior to the conversion of the calciner to in-bed combustion. In addition, most of the original NaK system was also removed, and the radiant coil in the NaK furnace was modified to heat fluidizing air.

The removal of most of the NaK heating system and the modification of the NaK furnace and its subsequent use to heat air reasonably ensures that no residual NaK remains in the NaK heating system.

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